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SUBSCRIBER LINE CONCENTRATORS

Contents

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers and other interested parties with information for use in the design, construction and operation of REA borrowers' telephone plant. More specifically, this section discusses subscriber line concentrators.

1.2 The first switching stage in a central office to which subscriber lines are connected can be called a "line concentrator." It is a stage that concentrates many subscriber lines to fewer common paths or links. In a step-by-step system the "line concentrator" is unidirectional. That is, traffic passes through in only one direction. This concentrator consists of the linefinder stage for originating traffic and the connector stage for terminating traffic. In most common control systems the "line concentrator" is bidirectional. It normally consists of the line link network used for both originating and terminating traffic.

1.3 The line concentrator stage in the central office is fundamental to reduce the central office equipment cost, but it does nothing to economize on the outside plant. An individual pair of wires or carrier channel is required to connect each subscriber line to the central office.

1.4 It is well known that the investment in outside plant is a large percentage of the total plant investment and with rising copper costs, this percentage will continue to grow.

1.5 Each telephone line is in use only a few minutes a day. At an average busy hour calling rate of 3.0 CCS per line, the average line is in use less than 10 percent of the busy hour. The high cost of outside plant coupled with its low utilization efficiency presents a major problem to telephone system planners and engineers.

1.6 Several attempts have been made in the past to improve the utilization efficiency of the line plant and thereby reduce its cost. The principle was to connect subscriber lines to a unit located close to the subscribers' premises and then connect this unit to the central office with common links.

1.7 Electromechanical line concentrators have been used for many years to reduce outside plant costs, but they failed to provide acceptable service at a reasonable cost. With the advent of digital transmission and integrated circuitry, the interest in line concentrators as a practical means to reduce the cost of outside plant has been renewed.

2. PRINCIPLES OF LINE CONCENTRATORS

2.1 The present-day concentrator consists essentially of two units: the remote unit installed at a suitable wire center located near the subscriber's premises, and the central control unit located at the central office. The remote unit may be pole mounted, installed in a suitable free-standing housing or hut or in another type of permanent building. The two units are connected by common pairs of wires or carrier channels called "links," which are switched to subscriber lines on originating and terminating calls. Figure 1 shows a line concentrator connected to a central office. Looking from the subscriber to the central office, the figure shows a concentrator stage at the remote unit to which the telephone lines are connected and an expansion stage at the central control unit to which the central office line circuits are connected. Each telephone line requires a line circuit at the remote unit as well as the regular line circuit at the central office.

2.2 Theoretically, it is more economical to eliminate the central office expansion stage. This is shown in Figure 2. With this arrangement, one line circuit per line will be required at the remote unit. No line circuits are required at the central office. At the central office the links will be connected to common circuits for outgoing and incoming traffic. The identity of the calling line will be transmitted to the central office only when identification is required. This is the normal arrangement for digital remotes connected to digital host offices. The analog signals are converted to digital at the remote unit and switched digitally at the host office.

2.3 By performing the concentration function remotely from the central office, a new balance between outside plant and switching costs may be obtained. In the past, the technical difficulties of maintaining complex switching equipment and the cost of administration of such equipment remotely have been formidable obstacles for the development of this type of line concentrator. However, recent developments in digital switching have overcome many of these obstacles. With digital switching systems, these remote concentrators are technically and economically feasible. Remote systems which do not have expansion stages at the central office are called "remote switching terminals" (RST) by REA. This section, however, is primarily concerned with line concentrators which employ concentration at the remote unit and expansion at the central office. REA's designation for this type of equipment is "subscriber line concentrator" (SLC). These concentrators are normally used with analog host offices.

2.4 Calls between subscribers served by the same line concentrator are designated "intracalls." These may be completed in one of two ways:

2.41 Two links between the remote unit and the central control unit are required; one link connects the calling line to the central office and the other connects the called line. The two links are switched at the central office and are held for the duration of the call.

2.42 Two links are used only during the time required to establish the connection. When the called party answers, the call is switched to an "intralink" at the remote unit. The two connecting links are then released and are free to accept other calls. The control unit at the central office monitors the line conditions at the remote unit over a data link and marks the line circuits busy at the central office end.

2.5 Intracalls can be a prime factor affecting the grade of service given to subscribers served by a line concentrator. Therefore, it is extremely important that the calling habits of the line concentrator subscribers be known. Unlike central offices, the traffic capacity of the system is expressed in terms of the number of links to the central office and the proportion of intracalls (or the number of intralinks).

2.6 The total traffic offered to the links in the two cases above can be expressed in terms of the outgoing traffic (O), the incoming traffic (I), and the originating intralink traffic (L), as follows:

a. Without Intralinks: $A = O + I + 2L$ (1)

b. With Intralinks: $A = O + I + \frac{2tL}{T}$ (2)

where "t" is the time needed to set up the connection and "T" is the call holding time. For example, if the time "t" is 15 seconds and the average call duration is 150 seconds, equation (2) becomes:

$$A = O + I + 0.2L$$

2.7 It is debatable whether the benefits of intralink switching justify the additional complexity and expense of providing it. It should also be noted that services such as busy verification, vertical services, and certain maintenance functions cannot be provided to subscribers using the intralink feature on subscriber line concentrators. The traffic impact of intracalls on systems with and without intralinks is studied in paragraph 6.

3. GRADE OF SERVICE

3.1 Subscribers served by a line concentrator should receive virtually the same service as would be given if they were connected to the central office by a dedicated pair of wires.

3.2 The grade of service assigned to dial tone should be that no more than 1.5 percent of the calls are to be delayed more than 3 seconds. Since the line concentrator is an additional concentration stage in the path of dial tone, it is necessary to divide the overall blocking between the line concentrator and the central office.

3.3 In order to determine the blocking between the subscriber and the central office, it is necessary to convert the blocking from terms of delay into terms of the Erlang B Loss Formula. The linefinder tables used in step-by-step systems are equivalent to about B.01 blocking based on the lost-calls-cleared assumption. The line concentrators are designed for a blocking of B.005. Therefore, when a subscriber is transferred to a line concentrator with no change in the existing central office, his total blocking will approach B.015 in the worst case. Theoretically, this may necessitate an additional trunk to bring the blocking back to B.01. However, B.015 is acceptable in this case and adding equipment to lower the blocking is not recommended.

4. TYPES OF LINE CONCENTRATORS

4.1 There are two major types of line concentrators in use today - analog and digital. These concentrators range in size from as little as 10 lines to as large as 256 lines or more. These lines can all be placed at one location or in certain systems distributed in several locations along the same cable route. The digital concentrators are connected to the central office by T-1 carrier, whereas the analog systems use either voice frequency trunks or carrier facilities.

4.2 Modern subscriber line concentrators are electronically controlled using solid-state components and integrated circuitry. These features enhance the reliability of these systems. The newest concentrators use microprocessors for control functions. These systems are not only very reliable but extremely flexible also.

5. LINE CONCENTRATOR APPLICATIONS

5.1 The subscriber line concentrator has many fields of use. The major applications are described in the following paragraphs.

5.2 Line concentrators can be used to provide telephone service more economically to rural subscribers by reducing outside plant costs through concentration of lines to the central office. Fewer cable pairs are needed in the backbone plant.

5.3 Upgrading from multiparty to single-party service can be done economically through the use of line concentrators. Using concentrators, upgrading can be accomplished without reinforcing main cable routes.

5.4 Line concentrators can be utilized to provide temporary service to trailer or camping parks, new housing developments, construction sites, resort areas and disaster areas. New cable plant expenditures can be deferred until a more complete picture of an area's growth can be obtained.

5.5 The replacement of small offices is another application for line concentrators. This use will not only save office codes but also provide subscribers in small exchanges with improved services, such as custom calling, by connecting them to a larger central office where these services are available.

6. INTRACALLS

6.1 One of the more common types of concentrator in one in which the remote unit is connected to th office by 24-channel PCM carrier. In certain cases t a total of 48 channels, are used. These systems can a maximum of 256 lines.

6.2 To study the impact of intracalls on the grade line concentrators with and without intralinks, concentrator will be considered. In all cases a grad of B.005 based on the Erlang Full Availability Traffi Lost-Calls-Cleared assumption, will be used.

6.3 Twenty-four (24) PCM channels can carry 511 busy hour CCS at B.005. Therefore, a 50-line concentrator can handle a combined originating and terminating calling rate of about 10 CCS per line where no intracalls are involved. Figure 3 shows the maximum combined calling rates for various size concentrators with various percentages of intracalls. These figures assume 24 links are equipped. The grade of service is B.005 and no intralinks are equipped. Figure 4 shows the maximum combined calling rates for various concentrator size with intralinks.

6.4 It can be seen from Figure 4 that the percentage of intracalls has little affect on the maximum calling rate in systems where intralinks are provided. Comparing Figures 3 and 4 shows that intralinks have a greater effect on the maximum calling rate as the percentage of intracalls increases.

6.5 To further study the impact of intracalls, a 150-line concentrator with 24 links will be discussed. It will be assumed that the combined originating and terminating traffic is 3.2 CCS per line, or 480 CCS total. This traffic offered to 24 links provides a grade of service better than B.005.

6.6 If this system is assumed to have an intracalling rate of 5 percent, the total traffic offered to the 24 links will be 504 CCS [480 + (.05) (480)] . From the traffic tables, it is seen that 24 links can handle this amount of traffic at B.005.

6.7 If the intracall rate is 10 percent, the traffic offered to the links will be 528 CCS [480 + (.1) (480)] . This traffic offered to 24 links will produce a grade of service less than B.005. To improve this grade of service, one of three things can be done: (1) provide an additional link, (2) decrease the calling rate, or (3) provide intralinks in certain applications. Which of these avenues to pursue is generally a matter of economics. In this case an additional link would give the desired B.005 grade of service; however, it would not be practical because an additional PCM system would have to be provided. The intracall traffic of 24 CCS could be handled with four intralinks at B.005. Assuming a call set-up time to call holding time ratio of 0.1, 2.4 CCS of additional traffic would be offered to the links, or a total of 482.4 CCS [480 + (.1) (24)] . Thus, the grade of service would be better than B.005.

6.8 From this example, it can be seen that with 24-channel PCM concentrators, intralinks are probably not required until the total traffic including the intracall traffic exceeds the capacity of the span. It is, therefore, very important that the calling habits of the concentrator subscribers be known. The calling habits of subscribers can, in many cases, be easily and economically determined through the use of the traffic monitoring options of the concentrators.

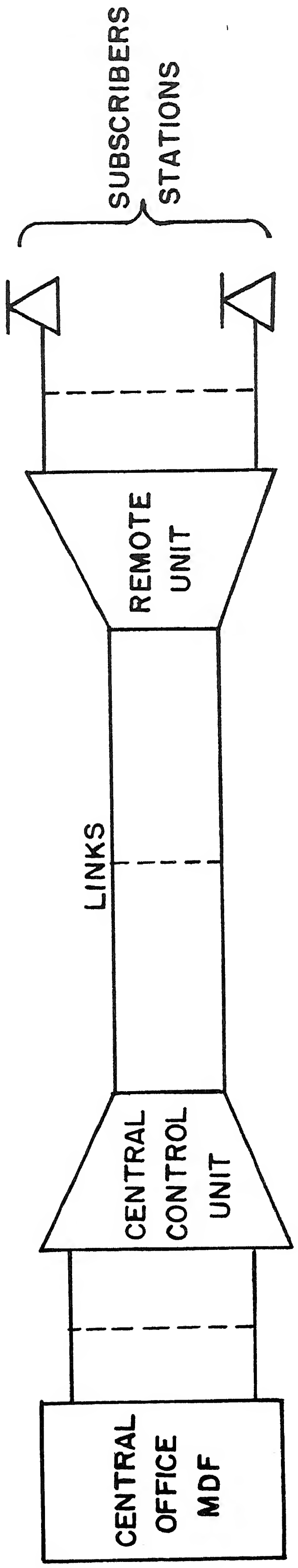

FIGURE 1—SCHEMATIC OF SUBSCRIBER LINE CONCENTRATOR

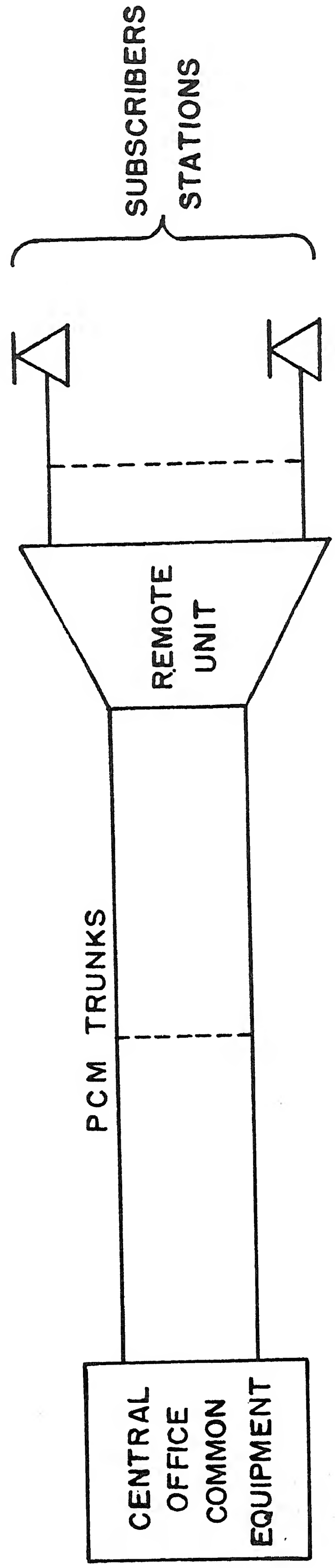

FIGURE 2— SCHEMATIC OF REMOTE SWITCHING TERMINAL

FIGURE 3
MAXIMUM COMBINED CALLING RATES FOR B.005 WITHOUT INTRALINKS

	Percent Intracalls						
Lines	0%	5	10	20	30	40	50
50	10.2	9.7	9.2	8.5	7.8	7.3	6.8
100	5.1	4.8	4.6	4.2	3.9	3.6	3.4
150	3.4	3.2	3.0	2.8	2.6	2.4	2.2
200	2.5	2.4	2.3	2.1	1.9	1.8	1.7
250	2.0	1.9	1.8	1.7	1.5	1.4	1.3

FIGURE 4
MAXIMUM COMBINED CALLING RATES FOR B.005 WITH INTRALINKS

	Percent Intracalls						
Lines	0%	5	10	20	30	40	50
50	10.2	10.1	10.1	10.0	9.9	9.8	9.7
100	5.1	5.0	5.0	5.0	4.9	4.9	4.8
150	3.4	3.3	3.3	3.3	3.3	3.2	3.2
200	2.5	2.5	2.5	2.5	2.4	2.4	2.4
250	2.0	2.0	2.0	2.0	1.9	1.9	1.9